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D E C I S I O N
of 5 December 1996

Case Number: T 0385/95 - 3.5.2

Application Number: 92600004.3

Publication Number: 0538172

IPC: H01F 29/02

Language of the proceedings: EN

Title of invention:
Voltage supply transformer

Patentee:
Matsakis, Nikolaos

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - (denied). Obvious design in view of given requirements"

Decisions cited:
-

Catchword:
-

Case Number: T 0385/95 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 5 December 1996

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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 12 December 1994 refusing European patent application No. 92 600 004.3 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: M. R. J. Villemin
J. -C. Saisset

Summary of Facts and Submissions

I. The Appellant contests the decision of the Examining Division to refuse European patent application No. 92 600 004.3. The reason given for the refusal was that the subject-matter of the claims then on file did not involve an inventive step. The following prior art documents were considered by the Examining Division:

D1 US-A-4 673 850
D2 FR-A-2 437 106.

II. In a first communication dated 13 September 1995, the Board expressed the provisional opinion that the Appellant's arguments were not convincing and cited the following additional document:

D3 Book "The Radio Amateur's Handbook", 27th edition, the HEADQUARTERS STAFF of the American Radio Relay League, West Hartford, Connecticut, U.S.A.; the Rumford Press, Concord, New Hampshire, U.S.A., 1950, pages 232 to 234.

III. In response to the above-mentioned first communication the Appellant filed with the letter dated 13 March 1996 new Claims 1 to 3 and a revised description of the application.

IV. In response to a second communication of the Board, annexed to the summons to oral proceedings, the Appellant cited with the letter dated 5 November 1996 the document:

D4 Book "Der Kleintransformator" by R. Kühn, C. F. Winter'sche Verlagshandlung, Prien, 1964, pages 206 to 209.

V. In the oral proceedings held before the Board on 5 December 1996, the Board further referred to pages 43 to 46 of document D3.

VI. In the course of the oral proceedings, the Appellant submitted a revised Claim 1. This Claim reads as follows:

"1. A transformer comprising a single core,

a primary coil having taps for supplying a first primary voltage and a second primary voltage,

and a secondary coil having taps for tapping at least one secondary voltage,

wherein said first primary voltage has a frequency of 50 Hz and said second primary voltage has a frequency of 60 Hz,

said primary coil having a predetermined value R/V as the number of turns per Volt,

and wherein the ratio of the number of turns between the taps of the primary coil to the number of turns between the taps of the secondary coil corresponds to the ratio of the respective primary voltage to the secondary voltage, characterized in that

said primary coil and said secondary coil are arranged such as to be electrically insulated from one another,

that said primary coil exclusively has two taps to which the first primary voltage or the second primary voltage are supplied,
that said first primary voltage is approximately 380 V and said second primary voltage is approximately 440 V,

that said secondary coil exclusively has a first, a second and a third tap,

that a secondary voltage of approximately 220 V can be tapped in the first primary voltage of 380 V between said first tap and said third tap, said third tap being the outer tap on the secondary coil,

or that a secondary voltage of approximately 220 V can be tapped in the second primary voltage of 440 V between said first tap and said second tap, located between said first and said third tap of said secondary coil,

and that the value R/V is determined from the equation R/V = 46/S for 380 V/50 Hz, wherein S is the cross-sectional area of said core in cm^2."

Claims 2 and 3 are dependent on Claim 1.

VII. The Appellant argued essentially as follows:

Document D1 suggested to use an autotransformer for transforming voltages at 50 Hz or 60 Hz. The present invention departed from this known principle by using a transformer having two separate coil windings electrically insulated from each other. This achieved the advantageous effect that both coils could be optimally adapted to the primary and the secondary currents and that the operational safety of the transformer was increased by the electrical insulation of the primary side from the secondary side. Starting from the transformer known from D1, the skilled person had to take several steps in order to arrive at the claimed transformer, including departing from the auto-transformer principle, minimizing the number of switch units and connection taps, simplifying the wiring on the primary side and finding a suitable value for the important parameter R/V.

As apparent from document D4, a non-ideal transformer showed hysteresis losses proportional to the frequency f, eddy current losses proportional to the square f^2 of this frequency and copper losses, which all significantly decreased its efficiency. If a higher frequency was used, the number of turns could be decreased, which reduced the length of the wire and therefore the copper losses. In a non-ideal transformer all frequency-dependent losses when using two different frequencies 50 and 60 Hz had considerable effects and therefore affected the transfer of electrical energy to a considerable extent.

The aim of the invention was to provide a transformer with an optimal efficiency at the frequencies of 50 and 60 Hz. Page 233 of document D3 recommended a value of R/V = 48.39/S at a frequency of 60 Hz, S being the cross-sectional area of the core in cm^2. This value differed by more than 5% from the claimed value 46/S which related to the operation at 60 and 50 Hz. The mean of the R/V values at 60 Hz and 50 Hz as deduced from D3 was greater by 15.5 % than the claimed value 46/S. Therefore, it was not known from the prior art to choose R/V = 46/S for a transformer operating at 50 Hz and 60 Hz in order to achieve optimum energy transfer while keeping losses low.

In response to observations made by the Board during oral proceedings the Appellant amended Claim 1 by mentioning that the value R/V = 46/S referred to the claimed transformer operating for a voltage of 380 V at 50 Hz. The Appellant further commented that the range of V values disclosed on page 46, right-hand column of D3, concerned a transformer operating at the frequency of 60 Hz. For a transformer operating at 50 Hz the calculated lowest value R/V of this known range turned out to be larger that the claimed 46/S value. This showed that D3 taught to operate a transformer at 50 Hz within a range of R/V values generally shifted towards higher R/V values than the value specified in the claim. Therefore, the subject-matter of Claim 1 involved an inventive step.

VIII. The Appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of Claims 1 to 3 filed in the oral proceedings held before the Board.

Reasons for the Decision

1. The Appeal is admissible

2. *Admissibility of the amendments in Claims 1 to 3*

In the opinion of the Board, Claims 1 to 3 presently on file do not contain amendments extending beyond the content of the application as originally filed and thus do not infringe Article 123(2) EPC. In particular, it is noted that since the ratio R/V is inversely proportional to the frequency f, it cannot be constant when f varies in a given transformer where the maximum flux density B and the cross-sectional area S of the core have predetermined values. Therefore the amendment in Claim 1 to specify that the value of R/V = 46/S applies to a voltage of 380 V at 50 Hz, which is consistent with the example in the originally filed description (see column 1, lines 40 to 46, of the published application), is admissible.

3. *Novelty*

In order to facilitate the discussion on patentability, the features of the transformer defined in Claim 1 will be designated by the references (a) to (m) as follows:

The claimed transformer comprises:

(a) a single core,

(b) a primary coil having taps for supplying a first primary voltage and a second primary voltage,

(c) a secondary coil having taps for tapping at least one secondary voltage, wherein

(d) said first primary voltage has a frequency of 50 Hz and said second primary voltage has a frequency of 60 Hz,

(e) said primary coil has a predetermined value R/V as the number of turns per volt,

(f) the ratio of the number of turns between the taps of the primary coil to the number of turns between the taps of the secondary coil corresponds to the ratio of the respective primary voltage to the secondary voltage,

and is characterized in that:

(g) said primary coil and said secondary coil are arranged such as to be electrically insulated from one another,

(h) said primary coil exclusively has two taps to which the first primary voltage or the second primary voltage are supplied,

(i) said first primary voltage is approximately 380 V and said second primary voltage is approximately 440 V,

(j) said secondary coil exclusively has a first, a second and a third tap,

(k) a secondary voltage of approximately 220 V can be tapped in the first primary voltage of 380 V between said first tap and said third tap, said third tap being the outer tap on the secondary coil, or

(l) a secondary voltage of approximately 220 V can be tapped in the second primary voltage of 440 V between said first tap and said second tap, located between said first and said third tap of said secondary coil, and

(m) the value R/V is determined from the equation R/V = 46/S for 380 V/50 Hz, wherein S is the cross-sectional area of said core in cm^2.

3.1 Document D1 describes a motor control system powered by an autotransformer 41 (see Figure 1) having voltage tapping points 11 to 16 supplying respective output voltage levels of 110, 100, 90, 80, 70 and 60 percent of that supplied by the line voltages L1 and L2. The Board agrees with the Appellant that D1 discloses the prior art closest to the claimed subject-matter and that features (a) to (f) constituting the prior art portion of Claim 1 are parts of the autotransformer known from this document. Since none of the remaining features (g) to (m) of the transformer is disclosed in D1, the subject-matter of Claim 1 is new over the autotransformer known from this prior art document.

3.2 Document D2 concerns a control system for supplying three-phase voltages by means of autotransformers. In comparison with that of D1 the teaching of this document appears to be less relevant to the claimed subject-matter.

4. *Inventive step*

According to the description of the application, the problem to be solved is the industrial manufacture of a transformer operating at 380 V/50 Hz or 440 V/60 Hz, wherein the output voltage at the secondary is unchanged.

No positive contribution to inventive step can be seen in formulating this problem, because Figure 1 of D1 already shows an autotransformer which may be supplied with different input voltages at 50 Hz and 60 Hz applied between L1 and one and the same tapping point 12.

The main issue to be considered in the present appeal is whether features (g) to (m) of the characterising portion of Claim 1 render inventive its subject-matter.

4.1 According to feature (g) the claimed transformer has two separate windings constituted by a primary coil and a secondary coil electrically insulated from one another. As far as security conditions are required, the advantages of a transformer with separate windings over an autotransformer are well known to the person skilled in the art. The arrangement according to feature (g) is very common in the field of transformers and its use cannot be regarded as introducing a surprising effect in the range of applications the claimed transformer is intended for, including applications in the merchant marine.

4.2 Features (h) and (i)

If the primary winding has the inductance L, the inductive reactance of this winding at a frequency f is $2\pi fL$ and, if one neglects the resistance of the primary winding, the ratio of the primary currents I_{50} and I_{60} corresponding to primary voltages 380 V /50 Hz and 440V /60 Hz, respectively, is:

$$I_{50}/I_{60} = (380/50) \times (60/440) \approx 1.036$$

$$\text{Therefore,} \quad I_{50} \approx I_{60}$$

Taking into account of feature (d) of the preamble of Claim 1, to have only two taps in the primary coil is an obvious choice when two voltages of 380 V / 50 HZ and 440 V/ 60 Hz are to be supplied to the primary coil because these two voltages can be applied to the same coil to produce almost identical current values, hence, approximately the same magnetic flux densities.

4.3 Features (j) to (l) relate to the choice of the number and the locations of the taps in the secondary coil and to the common value of 220 V of the voltage produced by the secondary when primary voltages of 380 V and 440 V are supplied to the transformer.

A transformer transforms electrical energy at one alternating voltage into electrical energy at another (usually different) alternating voltage without change of frequency. When it is desirable to produce various secondary voltage values from several primary voltage values, it is very common to provide both primary and secondary windings with tapping points. Since a voltage of 220 V is produced between the first and the third taps on the secondary coil when a voltage of 380 V (feature (k)) is applied to the primary coil, it is obvious that, when a voltage of 440 V is applied to the **same primary coil**, the number of turns on the secondary coil has to be reduced. It follows that the second tap has to be located **between** the first tap and the third tap of the secondary coil (feature (l)) in order to collect the same secondary voltage of 220 V.

The alleged simplified structure of the claimed transformer in comparison with the transformer disclosed in D1 merely reflects the fact that fewer voltage combinations are required in the claimed transformer than in the autotransformer disclosed in D1. The design and the operation of such an autotransformer are based on the same laws of induction as those governing the functioning of a transformer with separate primary and secondary windings. Figure 1 of D1 shows that a primary voltage value of 208 V, 50 Hz or a primary voltage value of 230 V, 60 Hz may be applied to the **same tapping point 12** of the transformer. It results that tapping point 12 and connection point between L1 and transformer coil 41 are comparable to the two tapping points of the primary coil of the claimed transformer. It is obvious to the skilled person dealing with transformers that this idea can be applied to transformers having two separate windings.

Given that generators are available which produce voltages of 380 V / 50 HZ and 440 V / 60 Hz and that many common electrical appliances are designed to operate on a 220 V AC supply, there is no particular merit in choosing primary voltage values of 380 V at 50 Hz and 440 V at 60 Hz to feed a transformer having two separate windings for producing a secondary voltage value of 220 V at 50 or 60 Hz, according to features k and l of the claim.

In view of the teaching of D1 combined with the general knowledge of the person skilled in the art of transformers, features (g) to (l) of the claimed transformer cannot render it inventive in the sense of Article 56 EPC.

4.4 According to feature (m), the value R/V = 46/S is determined for a voltage of 380 V at a frequency of 50 Hz. For the following reasons, the Board cannot be convinced by the Appellant's contention that this particular value renders the claimed transformer able to achieve an improved energy transfer while keeping transformer losses low.

4.4.1 It is shown in any textbook on transformers (e.g. see D4, formula (59)) that the following relationship

$$V = 4.44\ N \times f \times B \times S \qquad (1)$$

where V is a voltage of frequency f, B is the magnetic flux density and S the cross-sectional area of the magnetic core, applies to both primary and secondary coils of a transformer showing **no flux leakage**.

Replacing N by R as the number of turns, the number of turns per volt, R/V, can be deduced from (1):

$$R/V = K/S \qquad (2)$$

where K = 1/(4.44 x f x B) can be easily calculated since the quantities f and B are known. It is apparent that formula (2) corresponds to the formula

$$R/V = 46/S \qquad (3)$$

according to feature (m) of Claim 1, with K = 46. Since f is fixed at 50 Hz, the value 46 of K as mentioned in feature (m) corresponds to a particular choice of the value of the flux density B in the core of the claimed transformer. However, there is no indication in the present application as to how or why this value K = 46 has been chosen, or how it might improve the efficiency of the claimed transformer. Moreover, in the Board's opinion, it is not self evident that this particular choice of the magnitude of K could be of decisive importance in improving the efficiency of a transformer.

4.4.2 The application reveals nothing about the nature of the electrical conductors constituting the windings of the claimed transformer and the Board cannot see any reason why the claimed value R/V = 46/S should lead to a reduction of the resistive loss RI^2.

4.4.3 Furthermore, the penultimate paragraph of the right-hand column of the section "Transformer Construction" on page 46 of document D3 recites that "as a **rough average indication**, windings of small power transformers frequently have **about** six to eight turns per volt on a core of 1-square inch cross section" (emphasis added by the Board). This corresponds to the relation:

$$R/V = 6/S \text{ to } 8/S$$

which has the form of equations (2) and (3). Expressing now S in cm^2 rather that in square inch (1 square inch = 6.452 cm^2) we obtain

$$R/V \approx (6 \times 6.452)/S \text{ to } (8 \times 6.452)/S$$

$$\text{or: } R/V \approx 38.71/S \text{ to } 51.62/S$$

Since it can be admitted that D3 deals with R/V values at the American standard frequency of 60 Hz, these values have to be recalculated for 50 Hz. As can be deduced from the relation K = 1/(4.44 x f x B), the above mentioned values of R/V at 60 Hz should be multiplied by the conversion factor 60/50 = 1.2. This yields the result:

$$R/V \approx 46.45/S \text{ to } 61.9/S \text{ at } 50 \text{ Hz} \quad (5)$$

The lower value of R/V of the range disclosed by the prior art D3 is fairly close to that (46/S) claimed.

4.4.4 The Appellant has argued that the smallest value R/V = 46.45/S at 50 Hz deduced from D3 is larger than the claimed value R/V = 46/S at 50 Hz and that D3 in general taught using R/V values much larger than this claimed value.

The Board is not convinced that for transformers of typical sizes, a value R/V according to the equation R/V = 46/S provides a surprisingly better transfer of the energy from the primary side to the secondary side than an R/V value of, say, 46.5/S. The objection of the Appellant that no document shows the calculation of the value R/V is also not convincing since this calculation is known from the prior art and can be applied to any transformer of the type with which the present application is concerned.

5. In conclusion, no contribution to inventive step can be acknowledged to features (g) to (m) considered individually or in combination with all the other technical features of Claim 1, because they only belong to one among several possibilities from which the skilled man would select, without inventive step, for designing a transformer for a given particular requirement on basis of his general knowledge combined with the teaching of D1.

6. Summarizing, the subject-matter of Claim 1 does not involve an inventive step within the meaning of Article 56 EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Kiehl W. J. L. Wheeler